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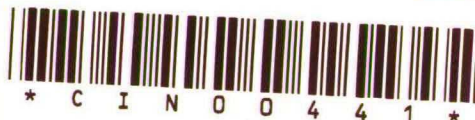
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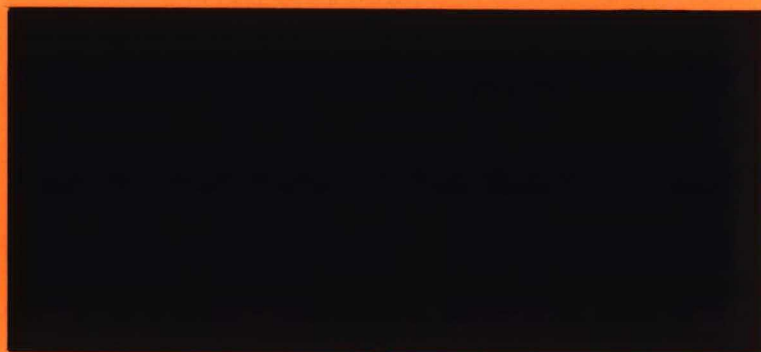
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TESTING KORTEWEG'S RATIONAL
EXPECTATIONS MODEL FOR A SMALL
OPEN ECONOMY

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April 1986

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TESTING KORTEWEG'S RATIONAL EXPECTATIONS MODEL FOR A SMALL OPEN ECONOMY

by Christian Mulder^{*}

SUMMARY

Korteweg extended the Barro, Lucas, Sargent, Wallace type of rational expectations model to a small open economy. This paper tests Korteweg's model with Dutch data. A major error in the specification and estimation is pointed out and corrected: the differenced expected variables are not defined consistently. This error implies that Korteweg's and Bomhoff's previous empirical results on the model are invalid. The test results for the corrected model indicate that this model has to be rejected for the Netherlands. The restrictions implied by an extremely simple empirical alternative are however not rejected.

1. INTRODUCTION

A new type a macro economic model emerged in the 1970's; a small model concentrating on a few macro economic variables, notably inflation, economic growth and unemployment. The new element in this type of model exists not so much in the traditional IS-LM demand side, as in the combination of a surprise supply equation and the rational expectations hypothesis. The names of Lucas, Sargent, Wallace, Barro and many others are associated with this approach (Lucas 1972, 1973, 1976, Sargent 1976, Sargent and Wallace 1975, Barro 1976, 1977, 1978).

These new rational expectations macro models draw a great deal of attention, both within and outside the profession. Their policy im-

^{*} I would like to thank Dr. Th. E. Nijman, Dr. F. van der Ploeg, Dr. W.H. Buiter, Dr. J.J.M. Theeuwes and Dr. A.J. de Zeeuw for their stimulus and helpful comments on previous versions of this paper. Responsibility for the contents remains of course with the author. Financial help, from the "Stichting Bekker-La Bastide-Fonds" and the "Stichting A.A. van Beek-Fonds" is gratefully acknowledged.

plications differ very strongly from the prevailing Keynesian policy prescriptions.

These rational expectations macro models favour a constant growth rule for the money stock and refute any Keynesian demand policy. Predictable Keynesian demand policy is completely ineffective in changing real variables such as the unemployment rate. In some cases fine tuning of the economy just increases the amplitude of the business cycles (Lucas 1973, Barro 1976).

The proponents of these models not only claimed to explain the empirical facts, they blamed the Keynesian paradigm for part of the unfavourable economic trends such as stagflation (Lucas and Sargent 1978). The international stagflation of the seventies was caused by failures of the Keynesian paradigm. The largely Keynesian based econometric models could not be used for policy evaluation because the 'fixed' model parameters were dependent on the policies which were being evaluated. The Keynesian models incorrectly assumed a trade off between unemployment and inflation, and suggested the possibility to balance unemployment at low levels. When exogenous shocks in the beginning of the seventies worsened the natural rate of unemployment this led Keynesian policy advisors erroneously to advice that unemployment could be reduced to old levels by demand management and expansionary monetary policy. These Keynesian policy reactions caused the (double digit) inflation of the seventies and did not succeed in bringing down unemployment according to the advocates of the New Classical school (Lucas and Sargent 1978), henceforward stagflation was explained and the Keynesians were blamed.

The remedy for the appearing international stagflation was simple. It amounted to a clear announcement of a low monetary growth policy. Such a policy (announcement) would be sufficient to make the economy return in a painless way to a low inflation path. Supply side economics was the code word for a stimulation of the micro economic adjustments necessary for a return of the natural rates to old or improved levels.

Korteweg can be placed within this trend. Korteweg's name is associated with the extension of the above described type of model to a small open economy.

The purpose of this article is to show a major inconsistency in Korteweg's approach and to present some empirical test results on the corrected model.

In section 2 Korteweg's model is expounded and related to the literature. The inconsistencies are discussed in section 3. The inconsistency arises because the various structural equations can only be interpreted for different definitions of the differenced expected variables. It is however easy to correct for this error once detected. The model with consistent definitions of the (differenced) expected variables is solved in section 4 and the test results are presented in section 5. Conclusions are drawn in section 6.

2. KORTEWEG'S MODEL

In subsequent articles, Korteweg's model evolved from an extended model with many behavioural relations (Korteweg 1977, 1978) to a three equation core model (Korteweg 1982) consisting of a demand, a supply and an unemployment equation.

In the extended model Korteweg basically followed a Keynesian approach on the demand side. The main categories of demand were distinguished and behavioural relations were specified for these categories. A traditional equation for money demand was specified and money supply was traced to its domestic and foreign origins. Korteweg's approximate solution of this set of relations is the following demand equation of the three equation core model:

demand equation:

$$\begin{aligned} \Delta Y_t = & \Delta YNE_t + \beta_1 (\Delta Mt - \Delta PE_t) + \beta_2 \Delta FI_t + \beta_3 (\Delta PF_t - \Delta P_t) \\ & + \beta_4 \Delta WT_t + v1_t \end{aligned} \quad (1)$$

with:

Y	Output of firms
M	Money stock, M1
P	Price level, Y deflator
FI	Fiscal Impulses, Government demand and influence on demand
PF	Foreign Prices
WT	World Trade
vi	are residuals (unspecified properties)
bi	are parameters

Variables are defined in log's. The prescript D indicates that the variables are differenced once. Hence DM is the first difference of log M, or (approximately) the rate of change of the money stock. The postscript N stands for natural. So YN is the natural output level. The postscript E indicates that the expected version of the variable is used. So DME is the expected rate of change of the money stock. The subscript t. The postscript t indicates the time period (discrete time).

Korteweg motivates this equation as follows: "The growth of real spending on output of firms by economic agents, public sector and foreigners (ΔY_t) is to be explained by the expected growth of real incomes (ΔYN), the interest and capital effects of changing real money balances ($\Delta M - \Delta PE$), where M represents the stock of money, fiscal impulses (FI), the difference in inflation with foreign countries ($\Delta PF - \Delta P$) and the growth of world trade (ΔWT)". The last two terms represent foreign influences and indicate the fact that the demand equation is the approximate solution of a model for a small open economy.

This demand equation may have some intuitive appeal, but it is not easy to relate her to standard behavioural equations such as the ones in Korteweg's own extended model, and still less to an optimizing framework with explicit utility functions, technologies and aggregation. One may question among other things the use of the natural rate of output with a coefficient of one, the use of the expected instead of the real inflation rate in the money balances term, the omission of the exchange rate in the foreign price term, the use of both real money balances and relative prices as exogenous variables (fixed and flexible exchange rate regimes are at work at the same time) and the omission of a

lagged price term (implied by the use of nominal interest rates in the money demand equation and real interest rates in the IS equation). Still Korteweg's approach is fairly sophisticated compared with some authors who just include unexpected money growth in ad hoc specified reduced form output, price or unemployment equations (e.g. Attfield, Demery and Duck 1981, Wogin 1980).

The supply side of both Korteweg's extended and his core model consist of a 'Lucas-Sargent-Wallace' surprise supply equation (in first differences).

supply equation:

$$\Delta Y_t = \Delta YNE_t + \alpha_1 (\Delta P_t - \Delta PE_t) + v2_t \quad (2)$$

with:

α_1 a parameter

This equation implies that output growth (ΔY) is at it's natural growth rate (ΔYNE) if the actual rate of inflation (ΔP) is equal to the expected rate of inflation (ΔPE). If inflation (ΔP) rises above the expected rate (ΔPE), output growth (ΔY) will rise above it's natural rate (ΔYNE).

The background of the supply equation involves many intricacies. Some authors take a market clearing assumption and imperfect information as their starting point in explaining the business cycle (Island parable, Lucas 1972, 1973, 1975, 1977, Barro 1976). Korteweg (Korteweg 1982) makes clear that he wants to adopt this approach.

Other authors embarked upon a non market clearing approach (Phelps and Taylor 1977, Fisher 1977). They seek the explanation of business cycles in institutional features such as fixed catalogue prices and overlapping labour contracts.

The policy implications differ widely with the origin of the supply curve. The institutionally underpinned supply curve makes fine tuning of the economy possible. The Lucas type market clearing approach leads to a constant growth rule for the money stock and the abolishment

of all demand management. Other policies would just increase the amplitude of the business cycle (Barro 1976, Lucas 1973).

It is hard to distinguish empirically between the various surprise supply curves and their underpinnings because the differences are rather subtle (Buiter 1983). Grossman (Grossman 1982) emphasizes that the empirical approximation of the supply equation Korteweg uses is incompatible with the market clearing approach, since he uses one year lagged information sets (see below).*

Unemployment is related to output surprises in more or less the same way as output is related to inflation surprises.

unemployment equation:

$$U_t = UNE_t - \alpha_2(\Delta Y_t - \Delta YNE_t) + v3_t \quad (3)$$

with:

U Unemployment rate
UNE Natural (expected) unemployment rate
 α_2 a parameter

The unemployment rate (U) is at its natural rate (UN), when output growth (ΔY) coincides with expected output growth (ΔYNE). When output increases unexpectedly, unemployment drops below its natural rate. Korteweg asserts that this equation is a variant of Okun's law (Okun 1962).

Korteweg assumes rational expectations for this model. Rational expectations are the expectations which are essentially the same as the predictions of the relevant economic theory i.e. the expectations which are consistent with the model equations (Muth 1961). Korteweg assumes a

* The perfect market clearing approach assumes imperfect information, but no delay in the use of information, whereas the overlapping wage contracts approach assumes perfect information but the impossibility to use information immediately. The latter approach corresponds to what Korteweg actually does.

complete but one period (one year) lagged information set, so in principle the rationally expected variables can be obtained by applying the rational expectations operator ($E\{X_t | I_{t-1}\} = XE_t$).

3. INCONSISTENCIES

The problem with the above structural form model is that the rational expectations operator for the differenced expected variables is not defined. One of the complications of rational expectations is that differenced expected variables can be defined in at least two different ways. In the first definition the information set is differenced as well: $\Delta XE1_t = E\{X_t | I_{t-1}\} - E\{X_{t-1} | I_{t-2}\} = XE_{t-1}$, where X is any variable, E is the rational expectations operator and I_t is the information set at time t , consisting of all variables and parameters up to and including time t . In the second definition the information set is not differenced:

$\Delta XE2_t = E\{X_t | I_{t-1}\} - E\{X_{t-1} | I_{t-1}\} = E\{X_t | I_{t-1}\} - X_{t-1}$. This is the usual definition.

In this empirical work Korteweg uses the second (standard) definition for the differenced expected variables (See appendix A for an illustration). However not all model equations (1)-(3) are interpretable with this definition of differenced expected variables. In the rest of this section this point will be elaborated. To avoid any further confusion of the definitions, a notation will be employed which is more explicit with respect to the information sets used:

$XE_t = E\{X_t | I_{t-1}\} = (\text{in shorthand}) X_{t|t-1}$. Note that $X_{t-1|t-1} = X_{t-1}$, so $\Delta XE2_t = X_{t|t-1} - X_{t-1|t-1} = X_{t|t-1} - X_{t-1}$.

What does the use of the second (empirical) definition imply for the above model of equations (1)-(3). Let us start with Korteweg's supply equation (2) and rewrite it using this second definition:

Korteweg's supply equation (2), using $\Delta XE2_t = X_{t|t-1} - X_{t-1}$:

$$\Delta Y_t = \Delta YNE2_t + \alpha_1 (\Delta P_t - \Delta PE2_t) + v2_t \quad (4)$$

Or:

$$\begin{aligned} Y_t - Y_{t-1} &= YN_{t|t-1} - YN_{t-1|t-1} \\ &+ \alpha_1 (P_t - P_{t-1} - P_{t|t-1} + P_{t-1|t-1}) + v2_t \end{aligned} \quad (4a)$$

Or:

$$Y_t = YN_{t|t-1} + \alpha_1 (P_t - P_{t|t-1}) + (Y_{t-1} - YN_{t-1}) + v2_t \quad (5)$$

The normal Lucas supply equation however has the following form (Lucas 1973)*:

Lucas's supply equation:

$$Y_t = YN_{t|t-1} + \alpha_1 (P_t - P_{t|t-1}) + v2_t^* \quad (6)$$

with:

$v1_t^*$ with noise residuals

So Korteweg implicitly assumed white noise residuals (which is usual in rational expectations models) and added $(Y_{t-1} - YN_{t-1})$ to the normal Lucas supply equation. This latter addition obviously implies an error. What does this error mean? It means that previous differences between the actual and normal output level always affect output. This can be seen by writing Korteweg's supply equation as follows:

Korteweg's supply equation (rewritten):

$$\begin{aligned} Y_t &= \alpha_1 \sum_{i=0}^{\infty} (P_{t-i} - P_{t-i|t-i-1}) + \sum_{i=0}^{\infty} (YN_{t-i|t-i-1} - YN_{t-i-1}) \\ &+ Y_{t-\infty} + \sum_{i=0}^{\infty} v2_{t-i} \end{aligned} \quad (7)$$

* The slow adjustment assumed by Lucas is omitted

The disturbing result is that past price forecast errors, past expected changes in the natural output level and residuals will influence output for ever! This is clearly an undesirable result and must rest on some error. Bomhoff (Bomhoff 1979) uses the same supply curve as Korteweg and thus makes the same mistake. Since equation (5) was used by both authors to compute the estimated reduced form equations, most empirical results in Bomhoff's PhD thesis (Bomhoff 1979) and Korteweg's articles on the model (Korteweg 1977, 1978, 1979, 1982) are invalid.

It is easy to check that with the other (i.e the first) definition for the differenced expected variables, Korteweg's equation would have corresponded to the Lucas_∞ supply equation, except for the residual structure (unless e.g. $v2_t = \sum_{i=0}^{\infty} v2_{t-1}^*$).

The same applies for the demand equation. Only with the first definition of the differenced expected variables and a specific residual structure (e.g. $vl_t = \sum_{i=0}^{\infty} vl_{t-1}^*$) is Korteweg's equation interpretable:

Korteweg's demand equation (1), using $\Delta XE1_t = X_{t|t-1} - X_{t-1|t-2}$:

$$Y_t = YN_{t|t-1} + \beta_1(M_t - P_{t|t-1}) + \beta_2 FI_t + \beta_3(PF_t - P_t) + \beta_4 WT_t + vl_t^* \quad (8)$$

With the second definition of the differenced expected variables, Korteweg's demand equation takes the following form (compare with (7)):

Korteweg's demand equation (1), using $\Delta XE2_t = X_{t \ t-1} - X_{t-1}$:

$$\begin{aligned}
Y_t = & \sum_{i=0}^{\infty} YN_{t-1|t-i-1} + \beta_1 \sum_{i=0}^{\infty} (p_{t-i|t-i-1} - p_{t-i-1}) \\
& + \beta_1(\pi_t - \pi_{t-\infty}) + \beta_2(FI_t - FI_{t-\infty}) + \beta_3(PF_t - PF_{t-\infty}) \\
& - \beta_3(P_t - P_{t-\infty}) + \beta_4(WT_t - WT_{t-\infty}) \\
& + \sum_{i=0}^{\infty} v1_t
\end{aligned} \tag{9}$$

With unemployment the situation is the other way round. Just with the second definition of the differenced expected variables does Korteweg's equation allow a meaningful interpretation:

Korteweg's unemployment equation (3), using $\Delta XE2_t = X_t|_{t-1} - X_{t-1}$:

$$U_t = UNE2_t + \alpha_2(\Delta Y_t - \Delta YE2_t) + v3_t \tag{10}$$

which is equivalent to:

$$U_t = UN_{t|t-1} + \alpha_2(Y_t - Y_{t-1} - Y_{t|t-1} + Y_{t-1|t-1}) + v3_t \tag{11}$$

Or:

$$U_t = UN_{t|t-1} + \alpha_2(Y_t - Y_{t|t-1}) + v3_t \tag{12}$$

This is the equation Korteweg uses in his extended model (Korteweg 1978) and the one which corresponds most closely to Lucas's supply equation (6).

Summarizing, there are (at least) two ways of defining differenced expected variables. Korteweg uses one of these definitions in his empirical work. This definition makes the unemployment equation in the theoretical part of his work interpretable. However the demand and supply equation in his model are only interpretable with the other definition for the differenced expected variables.

4. SOLUTION OF A CONSISTENT MODEL

A consistent version of Korteweg's model is easily obtained by taking the interpretable and meaningful equations (6), (8) and (12) (in log levels) as a starting point. Two of these equations (6) and (12) were specified as such by Korteweg in the extended version of this model in levels (Korteweg 1978).

It is easy to solve the model of equations (6), (8) and (12) in a consistent way. Since the expectations for variables in log levels are unambiguously defined by $XE_t = E\{X_t | I_{t-1}\}$, there can be no confusion of definitions of differenced expected variables. White noise residuals vi_t^* are assumed for each of the three equations ($i=1$ for demand, $i=2$ for supply, $i=3$ for unemployment).

Linear rational expectations model with lagged information sets are generally easy to solve (see e.g. Wallis 1980). In the case of the model consisting of equations (6), (8) and (12) one can proceed as follows. First equate the demand and supply curves. An equation for the rate of inflation results:

$$P_t = \frac{\alpha_1 - \beta_1}{\alpha_2 + \beta_3} PE_t + \frac{1}{\alpha_1 + \beta_3} \{ \beta_1 M_t + \beta_2 FI_t + \beta_3 PF_t + \beta_4 WT_t \} + \frac{1}{\alpha_1 + \beta_3} \{ v1_t^* - v2_t^* \} \quad (13)$$

Then this equation is solved for the expected price level, by applying the rational expectations operator $XE_t = E\{X_t | I_{t-1}\} = X_t |_{t-1}$. This results in (note that $E(vi_t | I_{t-1}) = 0$):

$$PE_t = \frac{\alpha_1 - \beta_1}{\alpha_1 + \beta_3} PE_t + \frac{1}{\alpha_1 + \beta_3} \{ \beta_1 ME_t + \beta_2 FIE_t + \beta_3 PFE_t + \beta_4 WTE_t \} \quad (14)$$

This result can be substituted in the supply, unemployment and price equations to form the following reduced form model:

price level:

$$\begin{aligned}
 P_t &= PE_t \\
 &+ \frac{1}{\alpha_1 + \beta_3} \{ \beta_1 (M_t - ME_t) + \beta_2 (FI_t - FIE_t) + \beta_3 (PF_t - PFE_t) + \\
 &\quad + \beta_4 (WT_t - WTE_t) \} \\
 &+ \frac{1}{\alpha_1 + \beta_3} \{ v1_t^* - v2_t^* \} \tag{15a}
 \end{aligned}$$

output:

$$\begin{aligned}
 Y_t &= YNE_t \\
 &+ \frac{\alpha_1}{\alpha_1 + \beta_3} \{ \beta_1 (M_t - ME_t) + \beta_2 (FI_t - FIE_t) + \beta_3 (PF_t - PFE_t) + \\
 &\quad + \beta_4 (WI_t - WTE_t) \} \\
 &+ \frac{\alpha_1}{\alpha_1 + \beta_3} \{ v1_t^* - v2_t^* \} + v2_t^* \tag{16}
 \end{aligned}$$

unemployment:

$$\begin{aligned}
 U_t &= UN_t \\
 &- \frac{\alpha_2 \alpha_1}{\alpha_1 + \beta_3} \{ \beta_1 (M_t - ME_t) + \beta_2 (FI_t - FIE_t) + \beta_3 (PF_t - PFE_t) + \beta_4 (WT_t - WTE_t) \} \\
 &- \frac{\alpha_2 \alpha_1}{\alpha_1 + \beta_3} \{ v1_t^* - v2_t^* \} + v2_t^* + v3_t^* \tag{17}
 \end{aligned}$$

Where the expected price level is:

$$PE_t = \frac{1}{\beta_1 + \beta_3} \{ \beta_1 ME_t + \beta_2 FIE_t + \beta_3 PFE_t + \beta_4 WTE_t \} \tag{15b}$$

The reduced form model of equations (15a)-(17) is the same as Korteweg's reduced form model except for the definition of the variables.

Every equation consists of an expected part XE_t and an unexpected part ($X_t - XE_t$). The difference between the actual endogenous variables P , Y and U and their natural/expected levels Y_N , PE and UN depends on the unexpected exogenous variables:

- the unexpected change of the money stock ($M_t - ME_t$)
- the unexpected change in the fiscal impulses ($FI_t - FIE_t$)
- the unexpected change in world trade ($WT_t - WTE_t$)
- the unexpected change in the world prices ($PF_t - PFE_t$)

These unexpected variables influence the endogenous variables in a similar way. This can be explained as follows: Unexpected price changes can easily be computed from equation (15a) as $P_t - PE_t$. Unexpected price changes explain unexpected output $Y_t - YN_t$ from equation (6), which in turn explains unexpected unemployment $U_t - UN_t$, from equation (12).

The policy implications of the model as it stands are straight forward. Unexpected monetary expansion ($M_t - ME_t$) will stimulate output and decreases unemployment. The same applies for unexpected fiscal impulses ($FI_t - FIE_t$), unexpected world trade ($WT_t - WTE_t$) and unexpected foreign price increases ($PF_t - PFE_t$). The beneficial effects disappear however the next period. Policies that affect the natural rate of output growth and unemployment are the only policies with lasting effects.

5. ESTIMATION AND TEST RESULTS

The above reduced form model consisting of equations (15a)-(17) can not be estimated as such. The natural rates of output and unemployment are not observed, neither are the expected and unexpected variables. Korteweg replaced the natural rates of output and unemployment by proxies and generated expected and unexpected series for the exogenous

variables from the estimation results for the exogenous variables.* The proxies for the natural rates are the ones set out in table I.

Table I Proxies for the natural rates

	Proxies Korteweg used Korteweg's model	Proxies used for the consistent version of
Output (ΔY)	c, $\Delta WTE2$, $\Delta VPE2$	c, $\Delta WTE1$, $\Delta VPE1$, ΔDN , ΔTSE
Unemployment (U)	c, $\Delta WTE2$, $\Delta VPE2$ $\Delta TSE2$, ΔDN	c, $WTE1$, DN , $TSE1$
Unemployment (ΔU) (first difference)		c, $\Delta WTE1$, $\Delta VPE1$, ΔDN ,
with:		
c	Constant	
VP	Variance of 235 prices	
TS	Taxes and social security premiums as a percentage of gross wages	
WT	World trade	
N	Population (14-64). DN is the rate of change.	

* To estimate the exogenous variables Korteweg employed Box-Jenkins time series analysis. All exogenous variables can be represented by univariate twice differenced, zero, first or second order moving average processes. From these processes the expected series (XE_t) result as the difference between observed and expected variables. This is one of the way's of dealing with the presence of unobserved expected and unexpected variables. See e.g. Wallis (Wallis 1980) for a different method and Begg (Begg 1982) for a discussion of some methods.

The motivation for the introduction of the extra proxies for the natural rate of output is that any variable which affects the natural rate of unemployment ought to affect the natural rate of output as well. The dimension of the proxies for the natural rate of unemployment is changed to bring them more in line with the other equations and the more correct theoretical form (equation (12)). Still it has to be born in mind that the proxies are very ad hoc and incomplete.

To compare Korteweg's empirical results with the results for the consistent version of his model ((15a)-(17) in reduced form), the same estimation period as Korteweg is used (1954-1978). For the same reason use is made of the processes for the exogeneous variables Korteweg established to generate the correctly defined expected variables, while the endogenous variables are estimated in basically the same dimension as in Korteweg's empirical work that is first differences.*

* It is very easy to estimate the reduced form model of equations (15a)-(17) in first differences: just difference all the variables in the (reduced form) equations and transform the series for the expected and unexpected variables in a similar way. To achieve this, Korteweg's unexpected series are first transformed to the log level form making use of definition two for the differenced expected variables. This log level form is required if one wants to estimate equations (15a)-(17). The obtained series in log level form are then differenced to be able to estimate equations (15a)-(17) in first differences. In effect one has changed the definition of the difference expected variables from definition two to definition one. See appendix B for data definitions and transformations.

The only problem lies in the residual structure. If one estimates the equations in first differences (to get rid of perfectly autocorrelated residuals?), one has to realize that the application of the rational expectations hypothesis changes the structure of the residuals. Perfectly autocorrelated residuals in equations (6), (8) and (12) are needed to obtain non autocorrelated residuals in the output and unemployment equation. The inflation equation will however still show some residuals autocorrelation under these assumptions, which ought to be detected by the Durbin Watson test statistic. If the residuals are autocorrelated the standard errors are inefficient and biased in normal ordinary least squares estimation.

Ordinary least squares estimation

The estimation results including a few statistics for a binary least squares (OLSQ) estimation are presented in the tables (II) - (V). For every variable, I first present the estimates for the equations Korteweg used (the estimates I obtained, employing the ordinary least squares procedure of the statistical package TSP version 4.0, are almost exactly the same as Korteweg's (Korteweg 1982)). Then I present the estimates for his specifications but with expected and unexpected variables generated in the correct way (consistent definitions of expected variables). Next I present the results for the model as it was specified theoretically (conform equations (15a)-(17)), i.e. without any ad hoc lagging, including, changing or omitting of variables as Korteweg did.

If the correctly generated expected and unexpected variables are used in Korteweg's inflation equation, six out of ten variables are insignificant at the 5% level, according to the t-ratio test (II.2). Two of these variables are the variables Korteweg arbitrarily included in his empirical specification, the change in taxes and social premiums as a percentage of national income ($\Delta TY_t - \Delta TYE_t$) and the dummy for the VAT (BTW) introduction in 1968.

If the theoretically derived equation (equation 15a + b) is estimated (III.3) instead of Korteweg's specification, four variables are insignificant. The estimated coefficients show a quite different pattern compared with Korteweg and lead to a rather different conclusion. The sum of the coefficient of expected money growth ($\beta_1/(\beta_1 + \beta_3)$) and the coefficient of expected international inflation ($\beta_3/(\beta_1 + \beta_3)$) is significantly different from one contradicting the underlying theory. The parameter estimates of the expected versions of the various variables appear to be quite close to the estimates of the unexpected versions of these variables. The hypothesis that the coefficient of the expected version is equal to the coefficient of the unexpected version can not be rejected for any of the four basic variables included.* E.g. the coeffi-

* Ofcourse one might reply that those results indicate that the coefficients α_1 and β_1 in the model are more or less the same. The results of the maximum likelihood estimation (see table VI) do not point to α_1 and β_1 being the same in a different direction.

cient of expected money growth ($\Delta ME2_t$) is not significantly different from the coefficient of unexpected money growth ($\Delta M_t - \Delta ME2_t$), implying that the actual money growth (ΔM_t) might as well have been used as a regressor.

Table II, inflation

II.1 Korteweg		II.2 Korteweg with - consistent definitions of expected variables		III.3 Korteweg with - consistent definitions of expected variables - theoretically derived specifications	
c	1.23 (1.60)*	c	1.39 (1.80)*	c	-0.21 (0.17)**
$\Delta ME2_{t-\frac{1}{2}}$	0.64 (5.02)	$\Delta ME1_{t-\frac{1}{2}}$	0.21 (2.09)	$\Delta ME1_t$	0.22 (2.33)
		$\Delta FIE1_t$		$\Delta FIE1_t$	0.43 (2.53)
$\Delta PFE2_{t-\frac{1}{2}}$	0.31 (4.04)	$\Delta PFE1_{t-\frac{1}{2}}$	0.44 (5.42)	$\Delta PFE1_t$	0.33 (3.44)
				$\Delta WTE1_t$	0.03 (0.26)**
$\Delta M_t - \Delta ME2_t$	0.12 (2.55)	$\Delta M_t - \Delta ME1_t$	0.06 (0.81)**	$\Delta M_t - \Delta ME1_t$	0.21 (2.51)
$\Delta FI_t - \Delta FIE2_t$	0.36 (4.35)	$\Delta FI_t - \Delta FIE1_t$	0.07 (0.63)**	$\Delta FI_t - \Delta FIE1_t$	0.32 (2.07)
$\Delta PF_t - \Delta PFE2_t$	0.13 (1.98)	$\Delta PF_t - \Delta PFE1_t$	0.11 (1.42)*	$\Delta PF_t - \Delta PFE1_t$	0.17 (0.97)*
				$\Delta WT_t - \Delta WTE1_t$	0.01 (0.11)**
$\Delta TY_{t-\frac{1}{2}} - \Delta TYE2_{t-\frac{1}{2}}$	0.56 (5.41)	$\Delta TY_{t-\frac{1}{2}} - \Delta TYE1_{t-\frac{1}{2}}$	0.19 (1.12)*		
DUM 68/69	1.46 (2.77)	DUM 68/69	1.04 (1.15)*		
R^2	0.90		0.71		0.65
DW	2.47		1.56		1.76
SSR	8.83		2.64		30.0

The OLSQ estimation results for the output equation confirms the picture of the inflation equation. Three coefficients are insignificant at the 5% level if the correctly generated expected variables are used (III.2) instead of the one's in Korteweg's empirical work (III.1). If a specification is used which is conform the theoretically derived equation (16), six variables become significant (at the 5% level) and both unexpected money growth ($\Delta M_t - \Delta ME2_t$) and foreign inflation ($\Delta PF_t - \Delta PFE2_t$) show an incorrect sign (III.3).

Table III, output

III.1		III.2		III.3	
Korteweg		Korteweg with - consistent definitions of expected variables		Korteweg with - consistent definitions of expected variables - theoretically derived specification	
c	1.55 (1.36)*	c	0.73 (1.02)*	c	2.13 (1.45)*
$\Delta WTE2_t$	0.42 (2.79)	$\Delta WTE2_t$	0.53 (6.17)	$\Delta WTE1_t$	0.62 (7.17)
$\Delta VPE2_{t-\frac{1}{2}}$	-0.37 (2.44)	$\Delta VPE1_{t-\frac{1}{2}}$	-0.23 (2.63)	$\Delta VPE1_t$	-0.12 (1.23)*
				$\Delta TSE1_t$	-0.03 (0.79)**
				ΔDN_t	-3.00 (1.69)*
$(\Delta M_{t-1} - \Delta ME2_{t-1})$	0.18 (2.18)	$(\Delta M_{t-1} - \Delta ME1_{t-1})$	-0.11*** 1.41*	$(\Delta M_t - \Delta ME1_t)$	-0.07*** (0.90)*
$(\Delta FI_t - \Delta FIE2_t)$	(0.31) (2.51)	$(\Delta FI_t - \Delta FIE1_t)$	0.29 (2.04)	$(\Delta FI_t - \Delta FIE1_t)$	0.36 (2.89)
$(\Delta WT_t - \Delta WTE2_t)$	0.34 (3.95)	$(\Delta WT_t - \Delta WTE1_t)$	0.50 (6.38)	$(\Delta PF_t - \Delta PFE1_t)$	-0.14***
$(\Delta YAG_t - \Delta YAGE2_t)$	0.10 (2.1)	$(\Delta YAG_t - \Delta YAGE1_t)$	0.04 (0.85)**	$(\Delta WT_t - \Delta WTE1_t)$	0.46 (5.29)
$(\Delta PI_t - \Delta PIE2_t)$	0.12 (2.82)	$(\Delta PI_t - \Delta PIE2_t)$	0.11 (2.3)		
R ²	0.82		0.80		0.76
DW	2.32		2.06		2.32
SSR	23.1		25.3		28.9

In Korteweg's estimation of the unemployment equation (IV.1) all unexpected variables were omitted (because of insignificance). If the correct expected variables are used in Korteweg's specification of the unemployment (IV.2), two variables out of five are insignificant (at the 5% level). Korteweg uses a strange dimension for the proxies for the natural of unemployment. If the proxies for the natural rates are undifferenced (IV.3) the fit of the equation improves already, though the Durbin Watson statistic points to misspecification or autocorrelated residuals. If the theoretically derived unexpected variables are included the equations improve even more (IV.4). Three out of four unexpected variables are significant at the 10% level, two of them at the 5% level. This compares favourably with Korteweg's equation. The picture remains the same if all dependant and independant variables are differenced, to make the dimension of the variables resemble the dimensions of the variables in the other equations more closely (IV.5). The variable TS performs well as a proxy for the natural rate of unemployment, indicating that unemployment can be brought down by reducing taxes and social premiums as a percentage of gross wages. The fact that this variable is rather insignificant in the output equation and not significant in the unemployment equation when all other insignificant variables are excluded casts however ample doubt on this conclusion.

Table IV, unemployment

IV.1 Korteweg		IV.2 Korteweg with - consistent defini- tions of expected variables		IV.3 Korteweg with - consistent definitions of expected variables - different dimen- sion of the natural rate proxies		IV.4 Korteweg with - consistent definitions of definitions of expec- ted variables - different dimension of the natural rate proxies - theoretically derived specification		IV.5 idem but differenced	
c	3.72 (4.28)	c	1.61 (2.25)	c	2.87 (3.40)	c	3.85 (7.12)	c	0.33 (0.60)**
$\Delta WTE2_{t-\frac{1}{2}}$	-0.53 (8.68)	$\Delta WTE1_{t-\frac{1}{2}}$	-0.22 (4.09)	$WTE_{t-\frac{1}{2}}$	-0.08 (4.77)	WTE_t	-0.09 (8.64)	$\Delta WTE1_t$	-0.11 (3.52)
$\Delta VPE2_{t-\frac{1}{2}}$	0.49 (4.57)	$\Delta VPE1_{t-\frac{1}{2}}$	0.09 (1.68)*	$VPE_{t-\frac{1}{2}}$	0.01 (0.39)**	VPE_t	-0.03*** (1.24)*	$\Delta VPE1_t$	-0.04 (1.05)
$\Delta TSE2_{t-\frac{1}{2}}$	0.07 (2.46)	$\Delta TSE1_{t-\frac{1}{2}}$	0.07 4.01	$TSE_{t-\frac{1}{2}}$	0.02 (2.18)	TSE_t	0.33 (4.92)	$\Delta TSE1_t$	0.03 (2.34)
ΔDN_t	1.18 (2.00)	ΔDN_t	1.60 (1.39)*	DN_t	-0.72*** (0.91)	DN_t	-0.55*** (1.07)	ΔDN_t	-0.49 (0.75)**
						$(M_t - ME_t)$	-0.01 (0.20)**	$(\Delta M_t - \Delta ME1_t)$	0.01 (0.49)**
						$(FI_t - FIE_t)$	-0.08 (1.70)	$(\Delta FI_t - \Delta FIE1_t)$	-0.02 (0.45)**
						$(PF_t - PFE_t)$	-0.13 (3.07)	$(\Delta PF_t - \Delta PFE1_t)$	-0.06 (1.54)*
						$(WT_t - WTE_t)$	-0.11 (4.30)	$(\Delta WT_t - \Delta WTE1_t)$	-0.11 (3.47)
R^2	0.90		0.61		0.78		0.91		0.49
DW	1.94		1.38		1.07		1.89		1.92
SSR	4.01		16.0		9.10		2.94		3.91

The OLSQ estimation results show how crucial it is to be careful when applying rational expectations and using artificially generated series as estimators. When the consistent version of Korteweg's model is estimated many variables become insignificant in every equation. The results point to some data mining as well. Almost all arbitrarily included variables are insignificant and various omitted variables are significant.

Full information maximum likelihood (FIML)

The model has been estimated using full information maximum likelihood methods as well. In this way the likelihood ratio test can be applied and the theoretical cross equation restrictions tested.*

The results for the best local maximum achieved are presented in table VI.

* Revankar (Revankar 1980) distinguishes between theoretical and empirical cross equation restrictions in a rational expectations context. Theoretical cross equation restrictions are the restrictions between variables (in the reduced form equations following from the specification of the equation. Empirical cross equation restrictions are the ones that follow from the way the rationally expected variables are estimated. E.g. if $X_t = a_1X_{t-1} + a_2X_{t-2} + v_t$, then $XE_t = a_1X_{t-1} + a_2X_{t-2}$. X_{t-1} and X_{t-2} could have been used as estimators instead of XE_t and the restrictions on the parameters can be tested, e.g. if XE_t appears in several equations. Because of the limited number of observations and the use of MA processes for the exogeneous variables it is hardly possible to test for the empirical cross equation restrictions in the above model.

Table VI, Full information maximum likelihood estimation results

Variable	Parameter		DW	SSR
	estimate	T-statistic		
β_1	-0.42	-3.20		
β_3	-0.57	-1.71		
β_2	0.24	0.97		
β_4	0.26	1.79		
α_1	-0.86	-1.82		
α_2	0.14	1.50		
Inflation equation			1.18	154.6
C	1.96	1.27		
Output equation			2.11	68.8
C	4.18	2.79		
$\Delta WTE2$	0.35	2.58		
$\Delta VPE2$	-0.18	-0.77		
$\Delta TSE2$	-8.75	-0.21		
ΔDN	-3.40	-1.00		
Unemployment (DU) equation			1.58	8.17
C	0.23	0.52		
$\Delta WTE2$	-0.058	-1.01		
$\Delta VPE2$	0.020	0.37		
$\Delta TSE2$	2.64	0.23		
ΔDN	-0.16	-0.15		
Log of likelihood = -118.614				

These estimates are not very exact. First of all FIML estimates, though more efficient than OLSQ results, are less robust because in FIML misspecification of one equation feeds through to the other equations. Second, the coefficient estimates, signs and significance appear to vary considerably in our case depending on the method through which convergence is achieved, the starting values etc... .

The likelihood ratio test however does not depend on the efficiency of the parameter estimates. For the best restricted FIML estimation in terms of log likelihood, the maximum likelihood ratio test

points to the rejection of the cross equation restrictions at the 99.5% level (i.e the restrictions are correct with (0.5% probability)!

Simple alternative

The OLSQ estimation results for the consistent model suggest a simple (empirical) alternative, an alternative in which the coefficients of the various expected variables are the same as the coefficients of their unexpected counterparts. If the other variables, except for a constant are omitted an alternative results in which no expected or unexpected variable plays a role. This model looks as follows:

$$\Delta P_t = c_1 + d_1 \Delta M_t + d_2 \Delta PF_t + d_3 \Delta FI_t + d_4 \Delta WT_t + \eta^1_t \quad (15)$$

$$\Delta Y_t = c_2 + d_5 \Delta WT_t + \eta^2_t \quad (16)$$

$$\Delta U_t = c_3 + d_6 \Delta WT_t + \eta^3_t \quad (17)$$

with:

c_i	constants
d_i	parameters
η_i	residual (i.i.d)

The restrictions embodied in this simple alternative compared with the consistent version of Korteweg's model can not be rejected at the 10% level (or more) for every single equation (F-test). The restrictions imbedded in the complete alternative can not be rejected at the 5% level according to the likelihood ratio test. These results clearly cast many doubts on the theory and assumptions in Korteweg's model. A model in which world trade growth is the only variable explaining output growth and unemployment, can not be rejected against Korteweg's model.

Expected economic policy

Another simple test is to examine whether expected economic policy affects real variables, contrary to the central conclusion of New Classical model such as Korteweg's, by including variables such as expected money growth, fiscal impulses and foreign inflation in the output

and unemployment equation of the consistent version of Korteweg's model. Only the variable FIE (expected fiscal impulses) in the output equation appears to be significant at the 10% level. So there is no clear empirical evidence that expected economic policy is effective in changing output growth and that the policy ineffectiveness proposal can be turned around (though these results may arise because of included variables misspecification).

Assesment

Are there any 'ad-hoc' reasons for these empirical results, such as an inadequate lag structure (e.g. due to adjustment costs), an incorrect functional form for the unemployment equation, inadequate data and proxies or an incorrect method to generate expected variables? Lag structures and different transformations for the unemployment equations have been tried but did not prove very succesfull. Mishkin's results (Mishkin 1982) indicate that the exact form of the unexpected variables does not make such a big difference. The proxies for the natural rates are of course not very exact and the definition of the fiscal impulses and the foreign price variables may be subject of discussion. It is almost impossible to provide a water tight empirical prive for the failure of a theory. The above results are however that stern that it can be concluded that Korteweg's model is inadequate.

6. CONCLUSIONS

There are (at least) two way's of defining difference expected variables. Korteweg uses one of these definitions in his empirical work. This definition makes the unemployment equation in the theoretical part of his work interpretable. However the demand and supply equation in his model are only interpretable with the other definition for the differenced expected variables.

It is relatively easy to correct for this error and derive a consistent version of Korteweg's model. This consistent version of

Korteweg's model is estimated and compared with Korteweg's previous results. The most prominent empirical findings are:

- 1) About half the variables in the consistent version of Korteweg's model are insignificant if the model is estimated conform the theoretically derived specifications.
- 2) The cross equation restrictions in the consistent version of Korteweg's model are clearly rejected (99.5% level of significance).
- 3) Coefficient estimates and tests on restrictions point to a simple alternative in which expected and unexpected variables are replaced by the actual observed variable.
- 4) Expected economic policy variables included in the output and unemployment equation are insignificant except for expected fiscal impulses in the output equation (marginally).

The basic conclusion which can be drawn is that Korteweg's model if derived and estimated in a consistent way, does not find support in the Dutch data. This applies a fortiori to the policy implications.

Bomhoff's assertive judgement (introduction to Korteweg 1982) that the model explains the major economic variables, such as inflation, output growth and unemployment very well, and Korteweg's forcible conclusion (Korteweg 1982), that unemployment can be reduced to around 3% by diminishing the government's share in the economy to the level of the early sixties can not be upheld in the face of such clear evidence.

APPENDIX A

Korteweg used the second definition for the differenced expected variables ($\Delta XE2_t = X_{t|t-1} - X_{t-1}$) in his empirical work. This assertion can be inferred from the way the expected and unexpected series are generated from the Box-Jenkins processes and can be illustrated for a twice differenced zero order moving average process, which was established for the money stock (Korteweg 1978) and foreign prices (Korteweg 1982) (e_t is an i.i.id. random variable).

Korteweg uses:

$$(A1) \quad \Delta M_t = e8_t$$

Or:

$$(A2) \quad M_t = 2M_{t-1} - M_{t-2} + e8_t$$

Taking rational expectations, using definition one ($\Delta XE1_t = X_{t|t-1} - X_{t-1|t-2}$) for the differenced expected variables one obtains:

expected money stock:

$$(A3) \quad M_{t|t-1} = 2M_{t-1|t-1} - M_{t-2}$$

$$(A4) \quad M_{t|t-1} - M_{t-1|t-2} = 2M_{t-1} - M_{t-1|t-2} - M_{t-2}$$

$$(A5) \quad \Delta ME1_t = \Delta M_{t-1} + (M_{t-1} - M_{t-1|t-2})$$

Alternatively taking rational expectations, using definition two ($\Delta XE2_t = X_{t|t-1} - X_{t-1}$) for the differenced expected variables one obtains:

expected money stock:

$$(A6) \quad M_{t|t-1} = 2M_{t-1|t-1} - M_{t-2}$$

$$(A7) \quad M_{t|t-1} - M_{t-1|t-1} = M_{t-1} - M_{t-2}$$

$$(A8) \quad \Delta ME2_t = \Delta M_{t-1}$$

Korteweg uses $\Delta ME_t = \Delta M_{t-1}$. Hence he uses definition two to generate expected and unexpected series, whereas he used definition one in (part of) his theoretical work. Similar results can be obtained for other variables.

Bomhoff (Bomhoff 1979) commits a similar error. The fact that Bomhoff uses the second definition of differenced expected variables in his empirical work (the same one as Korteweg), can be inferred from Bomhoff's equation 2.1, while he uses for example the same supply curve as Korteweg (Bomhoff's equation 2.5), which is only interpretable using definition one for the differenced expected variables (see section 3 of this paper).

APPENDIX B

Data Descriptions and Sources

Y	Gross output of firms, (Korteweg, National Accounts, CBS)
M	Money stock, M1, (Korteweg, DNB)
P	Price level, Y deflator, (Korteweg, National Accounts, CBS)
FI	Fiscal Impulses, Government demand and influence on demand (Korteweg, (Korteweg 1978))
PF	Foreign Prices, weighted OECD consumer price index (Korteweg, (Korteweg 1978))
WT	World Trade, weighted for the Dutch export structure (Korteweg, CPB)
U	Unemployment as a percentage of the dependent labour force (Korteweg, CBS)
c	Constant
T	Time trend
VP	Standard deviation of the rates of change of the prices of 235 products (Korteweg, (Korteweg 1978))
TS	Taxes and social security premiums as a percentage of gross wages (Korteweg, (Korteweg 1978))
N	Population in the age of 14 to 65 (Korteweg, (Korteweg 1978)), assumed to be perfectly predictable
YAG	Agricultural Production (Korteweg, National Accounts, CBS)
TY	Taxes and social security premiums as a percentage of national income (Korteweg, (Korteweg 1982))
PI	Import prices (Korteweg, (Korteweg 1982))
Dum	Dummy in 1968/1969 for the introduction of VAT (BTW)

Sources

DNB	Dutch Central Bank
CBS	Central Statistical Office
CPB	Central Planning Bureau
(Korteweg 1978)	Definitions according to (Korteweg 1978)
Korteweg	Data for (Korteweg 1982). I gratefully acknowledge that these data were available from the 'vakgroep Monetaire economie' Erasmus University, Postbus 1738 Rotterdam

Transformations and definitions of transformed data

Korteweg uses the following data and data definitions in his empirical work:

$$(B1) \quad \Delta X_t = X_t - X_{t-1}$$

$$(B2) \quad \Delta XE2_t = \Delta X_{t|t-1} = XE_{t|t-1} - X_{t-1|t-1} = XE_{t|t-1} - X_{t-1}$$

The X_t are exogeneous variables Korteweg used. The $XE2_{t-1}$ are the data Korteweg calculated from the MA time serie processes he established for the X_t , employing Box Jenkins time series analysis. The other data used in this article are obtained by applying the following transformations:

$$(B3) \quad X_t = \sum_{i=1954}^t \Delta X_i$$

$$(B4) \quad XE_t = \Delta X_t + \Delta XE2_t + X_t$$

$$(B5) \quad \Delta XE1_t = XE_t - XE_{t-1}$$

The data, the definitions (B1 and B2) and transformations (B3-B5), are consistent with the definitions (B6-B8) used in the theoretical part of this article.

$$(B6) \quad \Delta XE2_t = XE_{t|t-1} - X_{t-1}$$

$$(B7) \quad \Delta XE1_t = XE_{t|t-1} - XE_{t-1|t-2}$$

$$(B8) \quad XE_t = XE_{t|t-1}$$

Data

The data series for foreign prices are presented for illustrative purposes. The foreign prices obey the same stochastic process as the money stock in Appendix A.

	PF	PFE1	PFE2	PF	PFE
1952	1.38830	0.000000	0.000000	2.26740	0.000000
1953	0.336200	3.65570	1.38830	2.60360	3.65570
1954	0.336800	-0.715900	0.336200	2.94040	2.93980
1955	0.542300	0.337400	0.336800	3.48270	3.27720
1956	2.16740	0.747800	0.542300	5.65010	4.025500
1957	2.30250	3.79250	2.16740	7.95260	7.81750
1958	1.68320	2.43760	2.30250	9.63580	10.2551
1959	-0.0273	1.06390	1.68320	9.60850	11.3190
1960	0.990500	-1.73780	-0.0273	10.5990	9.58120
1961	0.795600	2.00830	0.990500	11.3946	11.5895
1962	2.27130	0.600700	0.795600	13.6659	12.1902
1963	2.37230	3.74700	2.27130	16.0382	15.9372
1964	2.01210	2.47330	2.37230	18.0503	18.4105
1965	3.03960	1.65190	2.01210	21.0899	20.0624
1966	3.34630	4.06710	3.03960	24.4362	24.1295
1967	2.67100	3.65300	3.34630	27.1072	27.7825
1968	2.20470	1.99570	2.67100	29.3119	29.7782
1969	3.98390	1.73840	2.20470	33.2958	31.5166
1970	5.07830	5.76310	3.98390	38.3741	37.2797
1971	6.01850	6.17270	5.07830	44.3926	43.4524
1972	8.73210	6.95870	6.01850	53.1247	50.4111
1973	13.1250	11.4457	8.73210	66.2497	61.8568
1974	10.9000	17.5179	13.1250	77.1497	79.3747
1975	11.6039	8.67500	10.9000	88.7536	88.0497
1976	3.70020	12.3078	11.6039	92.4538	100.358
1977	9.10190	-4.20350	3.70020	101.556	96.1540
1978	14.2558	14.5036	9.10190	115.812	110.658
	1	2	3	4	5

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